2-21-99-F-031

BIOLOGICAL OPINION SUMMARY
Reintroduction of Gila Topminnow and Desert Pupfish

Date of opinion: November 24, 1998

Action agency: Bureau of Land Management, Phoenix Field Office

Project: Reintroduction of Gila Topminnow and Desert Pupfish into Three Tributaries of the Agua Fria River

Location: Yavapai County, Arizona

Listed species affected: Gila topminnow, *Poeciliopsis occidentalis occidentalis*, endangered without critical habitat, and the desert pupfish, *Cyprinodon macularius*, endangered with critical habitat

Biological opinion: No Jeopardy

Incidental take statement:

Anticipated take: *Exceeding this level may require reinitiation of formal consultation.* Mortality will not be greater than an estimated 25 percent of each species being captured, stocked, held, including supplemental stocking. The Service anticipates incidental take of desert pupfish and Gila topminnow in the form of harassment, harm, and kill is expected from livestock grazing, recreation activities, road use, and prescribed burning. Take will be difficult to detect for these ongoing activities.

Reasonable and prudent measures: *Implementation of these measures through the terms and conditions is mandatory.*

1. Conduct ongoing actions in a manner which reduces habitat disturbance or disturbance or death to individuals. Most likely incidental take is related to the habitat surrogates defined above.

2. Provide a means to determine the level of incidental take that actually results from the project.

Terms and conditions: *Terms and conditions implement reasonable and prudent measures and are mandatory requirements.*

1.1 Notify the Service prior to stocking the sites. Use of Gila topminnows from other stocks or sources is permissible, and mixing of stocks may be suggested for conservation purposes in the future.

1.2 At Silver Creek, ensure grazing or recreational activity is managed such that less than 10 percent of streambanks are altered, that there is no loss of streambank cover from the present level, and that browsing on woody riparian seedlings is less than 30 percent.

1.3 Conduct prescribed burns such that no more than one-half of the watershed of each reintroduction site is burned in a two year period (excluding buffers to the streams) and repeat treatment at greater than two-year intervals.

2.1 At Silver Creek, monitor vegetation and streambanks of each site once each year, using accepted BLM methods.

2.2 Monitor desert pupfish and Gila topminnow populations and appropriate aquatic habitat variables at least once each year. Use accepted protocols in cooperation with AGFD and the Service with respect to augmentation periods and extirpation evaluations.

2.3 Monitor for fish kill immediately following the first runoff event after prescribed fires in the watershed.

2.4 A short report of the results of the monitoring, including complete and accurate records of all incidental take that occurred during the course of the project, will be submitted to the Service annually on the anniversary of the accompanying biological opinion. This report will also describe how the terms and conditions in this incidental take statement were implemented with respect to livestock grazing, recreation use, road use, and prescribed burns. This report may be consolidated with others or reports from sources than BLM may be acceptable as long as they address the above requirements.

Conservation recommendations: *Implementation of conservation recommendations is discretionary*. BLM could assist the Arizona Game and Fish Department in its monitoring program of extant populations of this species and identify more sites applicable to reintroduction in order to facilitate recovery of this species.

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In Reply Refer To:
AESO/SE
2-21-99-F-031

November 24, 1998

Memorandum

To: Field Manager, Phoenix Field Office, Bureau of Land Management, Phoenix, AZ

From: Field Supervisor

Subject: Formal Consultation on the Reintroduction of Gila Topminnow and Desert Pupfish into Three Tributaries of the Agua Fria River

This document transmits the Fish and Wildlife Service's biological opinion on the proposed Reintroduction of Gila Topminnow and Desert Pupfish into Three Tributaries of the Agua Fria River located in Yavapai County, Arizona, and its effects on the Gila topminnow, *Poeciliopsis occidentalis occidentalis*, endangered without critical habitat, and the desert pupfish, *Cyprinodon macularius*, endangered with critical habitat, in accordance with section 7 of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 et seq.). Your November 3, 1998, request for formal consultation was received on November 5, 1998.

This biological opinion is based on information provided in the November 3, 1998, biological evaluation, the November 1998, draft environmental assessment, telephone conversations of November 3, 4, and 9, 1998, with Tim Hughes, field investigations, and other sources of information. Literature cited in this biological opinion is not a complete bibliography of all literature available on the species of concern, species reintroductions, ongoing activities, or their effects, or on other subjects considered in this opinion. A complete administrative record of this consultation is on file at this office.

It is the Service's biological opinion that the proposed reintroduction of Gila topminnow and desert pupfish into three tributaries of the Agua Fria River is not likely to jeopardize the continued existence of the Gila topminnow, *Poeciliopsis occidentalis occidentalis* or the desert pupfish, *Cyprinodon macularius*.

BIOLOGICAL OPINION

DESCRIPTION OF THE PROPOSED ACTION

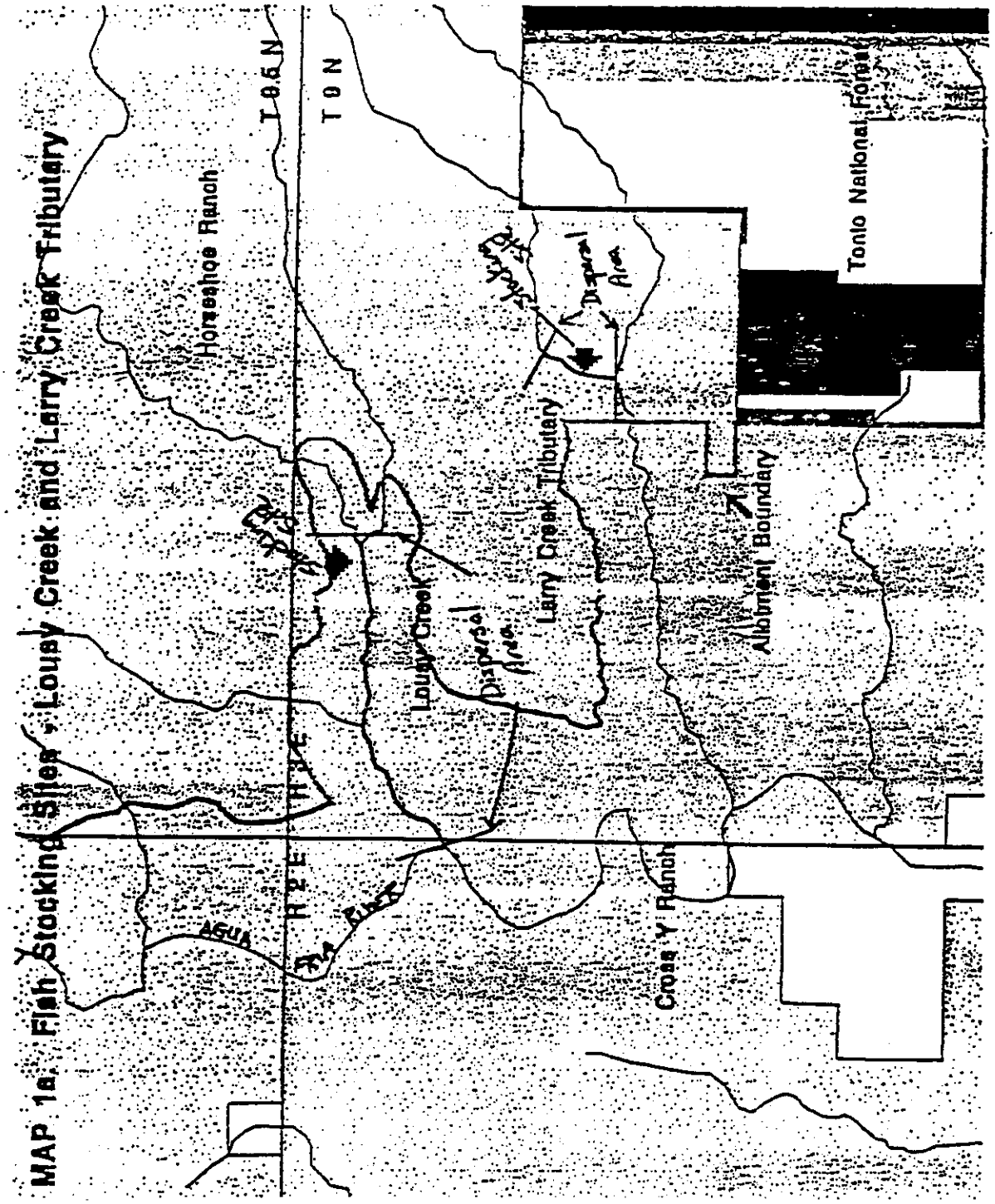
Fish Reintroduction

The U.S. Bureau of Land Management (BLM), Phoenix Field Office and Arizona Game and Fish Department jointly propose to reintroduce Gila topminnow and desert pupfish into three tributaries to the Agua Fria River north of Black Canyon City in Yavapai County, Arizona. The three sites are Lousy Canyon (T. 9 N., R. 3 E., Sec. 5), an unnamed tributary to Larry Creek (T. 9 N., R. 3 E., Sec. 9) and Silver Creek (T. 10 N., R. 3 E., Sec. 11). The reintroduction sites and expected maximum dispersal area for each site are depicted in Maps 1a and b. The expected maximum dispersal areas include all of the suitable habitat for these fish species contiguous with and downstream from the stocking sites. The dispersal areas have as their upper limit the drainage headwater and as their lower limit, the Agua Fria River occupied by predacious and competitive nonnative fishes. The Agua Fria River is not considered suitable habitat for either desert pupfish or Gila topminnow. Any movement of these two fishes into the Agua Fria River would be considered temporary and subject to 100% incidental take from nonnative fishes, and other activities. Future actions authorized or carried out by the BLM or private land owners within or along the Agua Fria River would not consider nor evaluate potential impacts on Gila topminnow or desert pupfish that may temporarily occur as a result of emigration from the three reintroduction sites listed above.

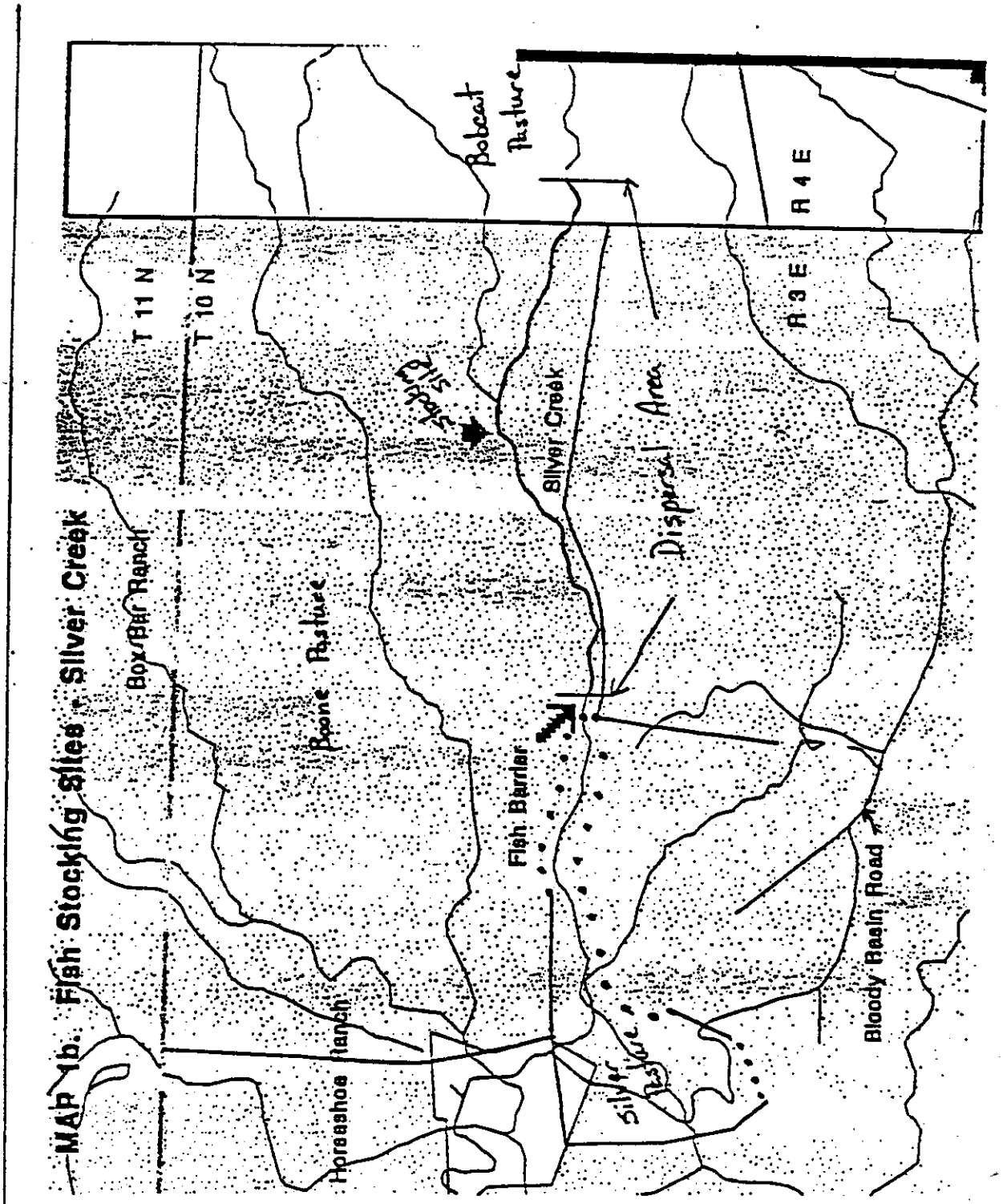
Each reintroduction site would be stocked with a minimum of 500 individuals of each species of fish. The origin of the desert pupfish stock for reintroduction would be Santa Clara Slough, Sonora, Mexico from Dexter National Fish Hatchery and Technology Center, New Mexico. Gila topminnow from Coal Mine Canyon would be stocked into the Tributary of Larry Creek. Topminnow from Fresno Canyon would be stocked into Lousy Canyon and topminnow from Lower Sonoita Creek would be stocked into Silver Creek. Gila topminnow population size at the donor source at the time of collection may necessitate stocking fewer than the 500 required. If this occurs, the collections/stockings may need to be conducted over the course of several years. If ongoing genetic research indicates all three of the natural source populations are the same, stocking of all three areas may occur using a single source. Gila topminnow would be collected during early summer (May-June) and stocked prior to the monsoon season. Desert pupfish would be stocked at the same time as the topminnow.

Supplemental stockings of Gila topminnow and desert pupfish would be carried out, as necessary, until a self-sustaining population of each species is established or until it is determined through monitoring that a site can not support a self-sustaining population. The determination as to whether the stocking efforts should be discontinued would be reached jointly by the BLM and Arizona Game and Fish Department. Annual monitoring of reintroduced fish populations to

Map 1a


MAP 1a. Fish Stocking Sites - Lousy Creek and Larry Creek Tributary
Horseshoe Ranch
T 6 N
T 5 N
R 2 E
R 3 E
Agua
Salt River
Lousy Creek
Lousy Creek Tributary
Larry Creek Tributary
Disposal Area
Disposal Area
Tonto National Forest
Abiment Boundary
Cross Y Ranch

Map 1b


MAP 1b. Fish Stocking Sites - Silver Creek
T 11 N
T 10 N
R 3 E
R 4 E
Box Bar Ranch
Boone Pasture
Horseshoe Ranch
Bobcat Pasture
Silver Creek
Dispersal Area
Fish Barrier
Silver Pasture
Bloody Basin Road

determine stocking success and evaluate the need for supplemental stockings would be conducted as a cooperative effort between the BLM and Arizona Game and Fish Department. The intent is for these three sites to have permanently established populations of both species.

Other Activities

The proposed action includes the continuation of all existing land uses (described below) in and around the three stocking sites.

Livestock Grazing

Livestock grazing on the BLM-administered Horseshoe and Cross Y Allotments and Forest Service administered Copper Creek Allotment, which include the three reintroduction sites, would continue at currently authorized levels. Grazing use may be modified by implementation of the Bureau's Standards and Guides for Rangeland Health or other BLM or Forest Service efforts designed to improve or maintain upland and riparian habitat conditions. No new range improvements are anticipated, but if they are proposed, appropriate effects evaluations would occur at that time.

Vehicle Crossings

There are two vehicular crossings on Silver Creek that would continue to be used at their current frequency and would be maintained as necessary to their current condition. The upper crossing is located at T. 10 N., R. 3 E., Sec. 11 SE1/4. This crossing is unimproved and used infrequently. The lower crossing is on the Bloody Basin Road at T. 10 N., R 3 E., Sec. 17 SE1/4. This crossing receives heavy vehicle use. The Bloody Basin Road is a maintained road with an improved crossing at Silver Creek. Vehicles may cross up to several hundred times per day at peak use. The creek is usually dry at this crossing point but water may be present at the crossing for several months, depending upon seasonal rainfall.

Prescribed Burns

The proposed action includes the continued use of prescribed fire by both the Tonto National Forest and the BLM, under a previous plan, on the semi-desert grassland uplands adjacent to, and within the watersheds of, all three reintroduction sites. Burns are carefully coordinated to burn the tobosa grass flatlands, not riparian areas or canyons. There are no 100 percent coverage fires. Mosaics are burned within the landscape. Coordination ensures only parts of watersheds are burned at any one time. Only light fugitive retardant is used on mesa tops, if needed. No cyanide based sodium ferrocyanide from heavy air tankers is used on the mesa.

Conservation Measures

The proposed action is a conservation measure designed to contribute toward the recovery of this species. All future actions in the vicinity of the three stocking sites, not covered by the proposed action, would be assessed for impacts to desert pupfish or Gila topminnow prior to authorization.

STATUS OF THE SPECIES

Gila Topminnow

The Gila topminnow was listed as an endangered species on March 11, 1967, without critical habitat (DOI 1967). The Gila topminnow is a small, livebearing fish found in the Gila, Sonora, and de la Concepcion River basins in Arizona, New Mexico, and Sonora, Mexico (Minckley 1973, Vrijenhoek *et al.* 1985), but is listed only in the United States. It was once among the commonest fishes of the Gila River Basin (Hubbs and Miller 1941). Destruction of its habitat through water diversion, stream downcutting, backwater draining, vegetation clearing, channelization, water impoundment, livestock grazing, and other human uses of natural resources; plus competition with and predation by nonnative fish species, most notably mosquitofish, have resulted in extirpation of the Gila topminnow throughout most of its range (Meffe *et al.* 1983, Service 1984).

Male Gila topminnow are smaller than females, rarely greater than one inch, while females are larger, reaching two inches. Body coloration is tan to olivaceous, darker above, lighter below, often white on the belly. Breeding males are usually darkly blackened, with some golden coloration of the midline, and with orange or yellow at base of the dorsal fin. Fertilization is internal and sperm packets are stored which may fertilize subsequent broods. The brood development time is 24 to 28 days. Two to three broods in different stages develop simultaneously in a process known as superfetation. Gila topminnow give birth to 1-31 young per brood (Schoenherr 1974). Larger females produce more offspring (Minckley 1973).

Gila topminnow mature a few weeks to many months after birth depending on when they are born and water temperature. They breed primarily from March to August, but some pregnant females occur throughout the year (Schoenherr 1974). Some young are produced in the winter months. Minckley (1973) and Constantz (1980) reported that Gila topminnow eat bottom debris, vegetation, amphipods, and insect larvae when available.

Gila topminnow and many other poeciliids can tolerate a wide variety of physical and chemical conditions. They are good colonizers in part because of this tolerance and in part because one gravid female can start a population (Meffe and Snelson 1989). Minckley (1969, 1973) described their habitat as edges of shallow aquatic habitats, especially where abundant aquatic vegetation exists.

Gila topminnows are known to occur in streams fluctuating from 43 to 97°F, pH from 6.6 to 8.9, dissolved oxygen levels of 2.2 to 11 milligrams/liter, and can tolerate salinities approaching those of sea-water (Meffe *et al.* 1983). Topminnows can burrow under mud or aquatic vegetation when water levels decline (Deacon and Minckley 1974, Meffe *et al.* 1983). Sonoran topminnows, *Poeciliopsis occidentalis*, regularly inhabit springheads with high loads of dissolved carbonates and low pH (Minckley *et al.* 1977, Meffe *et al.* 1983, Meffe and Snelson 1989). This factor has helped protect small populations of topminnows from mosquitofish which are usually rare or absent under these conditions.

To summarize the Gila topminnow habitat requirements, this fish needs: 1) unpolluted water that can have wide variation in temperature, pH and salinity, 2) shallow water with abundant aquatic plants including algae that provide cover and habitat for invertebrate prey, 3) channel morphology that prevent habitats from scouring severely, which otherwise may remove this weak swimmer from its habitat, 4) habitat areas free of nonnative competitors and predators, and 5) areas with slow currents and soft bottoms.

Desert Pupfish

The desert pupfish was listed as an endangered species, with critical habitat, on 30 April 1986 (Service 1986). The name desert pupfish is often incorrectly applied to all 10 pupfish species in the American Southwest (Williams *et al.* 1989, Pister 1996). There are two recognized *Cyprinodon macularius* subspecies, *C. m. macularius* and *C. m. eremus* and one undescribed form (McMahon and Miller 1985, Miller and Fuiman 1987). Critical habitat has been designated in Arizona at Quitobaquito Spring and in California along parts of San Felipe Creek, Carrizo Wash, and Fish Creek Wash (Service 1986).

The desert pupfish is a member of the family Cyprinodontidae. Desert pupfish are usually less than 3.0 in. total length; adults are more often 1.6-2.0 in. Males are larger than females and become bright blue during the breeding season.

Under the proper conditions, desert pupfish may begin breeding as early as six weeks of age. However, most breeding does not occur until their second summer (Moyle 1976). Male pupfish are intensely territorial during the breeding season. The males patrol and defend individual territories that are 5.4 to 22 ft^2 and in water less than three ft deep (Barlow 1961, Minckley 1973, Moyle 1976).

The desert pupfish breeding system includes consort-pair breeding and territoriality (Service 1993). Territoriality develops in large habitats with high primary productivity, limited breeding substrates, and high population densities. Consort-pair breeding usually occurs in habitat with low primary productivity, low population density, or abundant breeding habitat (Kodric-Brown 1981). Female desert pupfish lay only one egg at a time (Constanz 1981). However, one female may

produce 50-800 eggs in one season (Crear and Haydock 1971). The life span of an individual is one to three years in the wild (Minckley 1973, Moyle 1976, Kynard and Garrett 1979).

Larval desert pupfish feed on invertebrates (Crear and Haydock 1971). Adult pupfish are omnivorous and may feed on algae, invertebrates, detritus, and plants (Cox 1966, 1972; Naiman 1979). Pupfish are active during the day. Desert pupfish have been found in a variety of habitats, from the margins of large rivers to springs to cienegas. Pupfish can survive extremely harsh conditions that are lethal to most other fishes. They can survive temperatures up to 113°F (Lowe *et al.* 1967), dissolved oxygen concentrations to 0.1-0.4 mg/l (Barlow 1958), and high salt concentrations of 68 g/l (Lowe *et al.* 1967). Pupfish can also tolerate sudden changes in both temperature and salinity (Kinne 1960, Lowe and Heath 1969).

Historical distribution of desert pupfish included the Gila River basin, the lower Colorado River, the Rio Sonoyta basin, the Salton Sink basin, and the Laguna Salada basin (Eigenmann and Eigenmann 1888, Garman 1895, Gilbert and Scofield 1898, Evermann 1916, Thompson 1920, Jordan 1924, Coleman 1929, Jaeger 1938, Miller 1943, Minckley 1973, 1980; Black 1980, Turner 1983, Miller and Fuiman 1987). Historic collection localities occurred in Mexico, in Baja California and Sonora, and in the United States, in California and Arizona. Populations and distribution probably expanded and contracted historically as regional and local climatic conditions varied.

Thirteen natural populations persist; nine of these are in Mexico. Approximately 20 transplanted populations exist in the wild (Service 1993). Many natural and transplanted populations are imperiled by one or more threats. Threats to the species include loss and degradation of habitat through groundwater pumping or diversion, predation and competition from nonnative fish species, populations outside of historic range, populations of questionable genetic purity, restricted range, small populations, and environmental contaminants (Service 1984).

ENVIRONMENTAL BASELINE

The environmental baseline includes past and present impacts of all Federal, State, or private actions in the action area, the anticipated impacts of all proposed Federal actions in the action area that have undergone formal or early section 7 consultation, and the impact of State and private actions which are contemporaneous with the consultation process. The environmental baseline defines the current status of the species and its habitat in the action area to provide a platform to assess the effects of the action now under consultation.

Silver Creek, Lousy Creek and Larry Creek Tributary are within the Agua Fria Grasslands ecosystem. The upland areas surrounding these three sites are semi-desert grasslands dominated by tobosa grass, curly mesquite and red brome. The sides of the drainages are occupied by shrub live oak, catclaw, netleaf hackberry and juniper. Riparian vegetation is dominant along the three

streams. Water rights claims for Silver Creek came from the Arizona State Land Department with the Santa Rita Land Exchange. BLM holds water rights for stock and wildlife on all three sites and the grazing permittee for each area also claims water rights for stock and wildlife. Silver Creek has a stock and domestic filing, but the point of diversion is below the area where the fish are anticipated to expand into.

The Agua Fria River downstream of all three stocking sites is occupied by green sunfish and mosquitofish. These two nonnative fishes represent a biological barrier that would preclude both topminnow and pupfish from becoming established outside the maximum dispersal area.

Silver Creek

The perennial reach of this stream starts on the Tonto National Forest, approximately 0.25 mile east of the boundary with the BLM administered lands and runs westerly for approximately four miles to a point approximately 0.5 mile above the Bloody Basin Road where it flows underground. Through this reach the stream is an alternating series of riffles, runs and pools. The elevation at the upper end of this reach is 3,760 feet. At the lower end of the reach the elevation is 3,320 feet. The creek is interspersed with an often dense overstory canopy of velvet ash, cottonwood, Goodding's willow, Arizona sycamore and open areas. Understory species include seep willow, red brome, bulrush and Bermuda grass. Riparian obligate wildlife species found along this reach include lowland leopard frogs, canyon tree frogs and common black hawks.

The stream reach, approximately one mile downstream of the road crossing in Section 11, includes a narrow gorge that contains a five foot high waterfall. This waterfall apparently serves as a barrier to fish movement upstream. Based on numerous fish sampling efforts above and below this waterfall, only Gila chub occur above the barrier while green sunfish, fathead minnow, longfin dace, Gila mountain sucker and Gila chub occur below the barrier.

The upper two miles of Silver Creek, below the National Forest Boundary, is considered Functioning at Risk with an upward trend. The 0.25 mile reach on the Tonto National Forest and the reach between two and four miles downstream of the Forest boundary are considered to be in Proper Functioning Condition. The one mile reach above the confluence with the Agua Fria River is considered to be Functioning at Risk with an upward trend. This condition assessment was conducted in 1998 by BLM personnel. All riparian habitat assessments follow the BLM Technical Reference, 1737-9, 1993, "Process for Assessing Proper Functioning Condition".

Lousy Creek

The perennial reach of this stream flows for approximately one mile downstream of the spring source, from an elevation of 3080 feet to 2600 feet. This reach flows through a steep, narrow, boulder-strewn gorge with several waterfalls. The upper waterfall is approximately 30 feet high

with a large plunge pool (30 x 10 x 15 feet deep). Another, smaller waterfall (approximately 15 feet high) occurs approximately 100 yards below the larger has no associated plunge pool. The vegetative overstory of large velvet ash, Arizona sycamore, cottonwood and willow shades most of the reach. Where there is no overstory, bulrush, seep willow, canyon grape and common reed occur along the margins of the numerous pools. The stream channel consists of mostly pools with a few shallow runs. Below the smaller waterfall, longfin dace occur in the stream. Between the two waterfalls, Gila chub were reintroduced in 1995 and have become established. No fish exist above the larger waterfall. Lowland leopard frogs, canyon tree frogs and common black hawks occur along this reach. The riparian habitat along the entire reach of Lousy Canyon from the source downstream to the confluence with the Agua Fria River is considered to be in Proper Functioning Condition.

Larry Creek Tributary

The perennial reach of this stream is approximately ½ mile long. This reach starts at an elevation of 3,200 feet and drops to 2,860 feet. It flows down a narrow canyon as a series of pools and runs to the confluence with Larry Creek. Larry Creek, below this confluence, is dry except for a few pools. The vegetative overstory is dense stands of velvet ash, Arizona sycamore, cottonwood and willow. The stream channel is lined with thick stands of common reed, bulrush and seep willow. Gila chub were reintroduced in 1995 and have become established. Lowland leopard frogs, canyon tree frogs and common black hawks occur along this reach.

The riparian habitat condition along the entire reach of the Tributary to Larry Canyon from the source downstream to the confluence with the Larry Canyon is considered to be in Proper Functioning Condition.

Livestock Grazing: Most of Silver Creek is within the Boone Pasture of the Horseshoe Ranch. The lower end of Silver Creek is in the Silver Pasture. The upper most perennial reach of Silver Creek (0.25 miles) is on the Tonto National Forest in the Bobcat Pasture on the Copper Creek Allotment. The Copper Creek Allotment and the Horseshoe Allotment are operated jointly as the Horseshoe Ranch operated under a coordinated resource management plan cooperatively developed by the BLM and Forest Service. All of these pastures are authorized to be grazed between November 1 and March 1 annually, but actual use will not exceed two months during this time frame. The riparian condition along two miles of Silver Creek is proper functioning. The remaining three miles of Silver Creek is currently functioning at risk with an upward trend. The short reach on the Tonto National Forest is proper functioning. The entire stream is expected to be in proper functioning condition within three to five years and would remain so under the proposed alternative. The pasture configuration along Silver Creek is depicted on Map 1b.

The tributary of Larry Creek is in the Lousy Pasture on the Horseshoe Ranch. Lousy Creek is in Lousy Canyon in the Cross Y Allotment. Due to topography, neither of these two streams is

ever used by livestock. Both areas are currently in proper functioning condition and would remain so with the implementation of this proposed alternative.

The Horseshoe Ranch (both Horseshoe and Copper Creek Allotments) is authorized 9072 animal unit months (AUMs) annually and is operated with a rest-rotation grazing system. The Horseshoe Ranch maintains a base cow/calf herd of approximately 450 animals but actual numbers may fluctuate from 375 to 950 depending on forage availability and pasture scheduling.

The Cross Y Allotment is authorized 2,790 AUMs annually. This allotment is operated with a rest rotation grazing system.

Recreation: Recreational use in the vicinity of Silver Creek is light. It consists mostly of dispersed use associated with equestrian use and small and big game hunting. Lousy Canyon and the tributary of Larry Creek are visited infrequently by hikers.

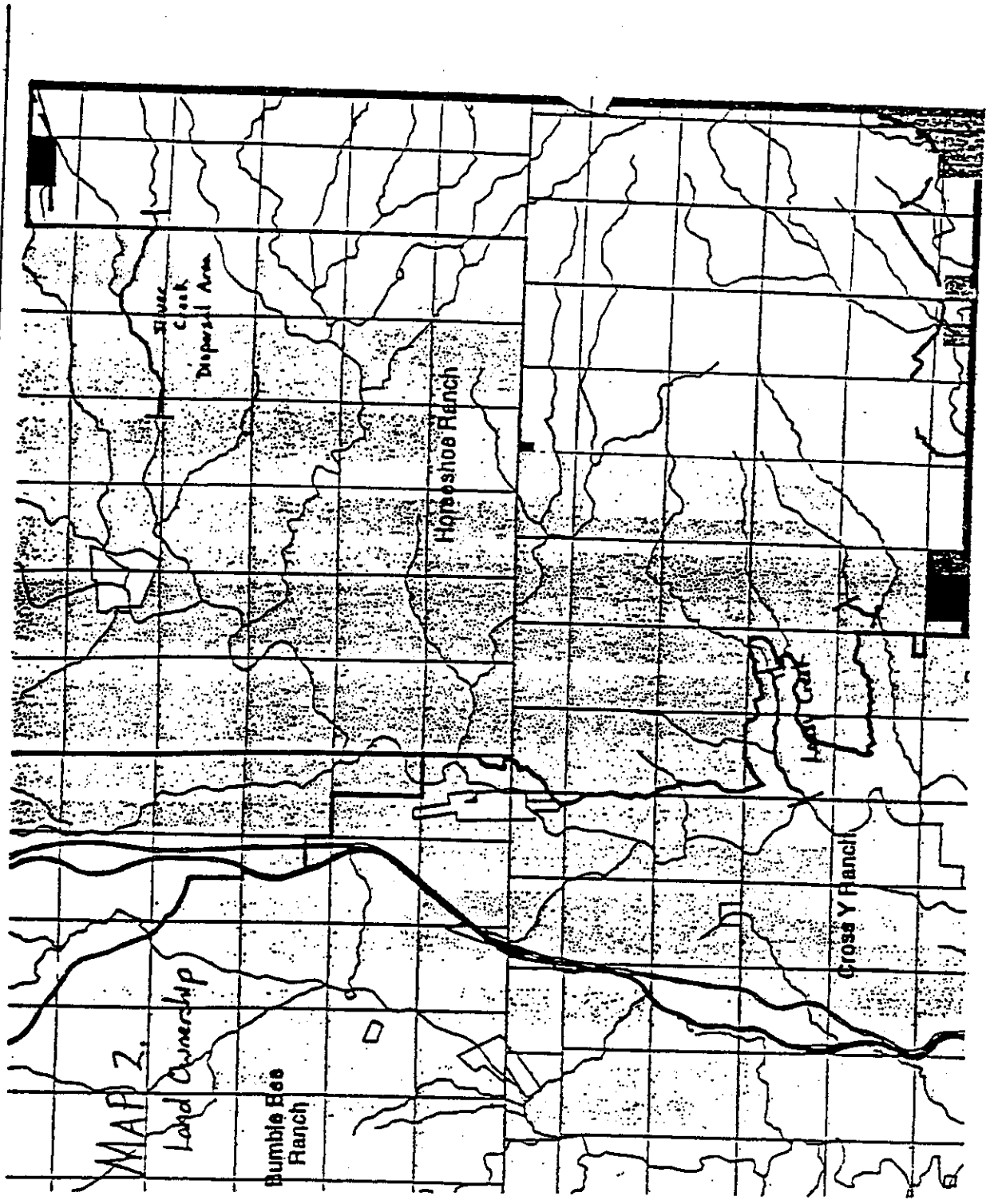
Areas of Critical Environmental Concern: The Larry Creek tributary is inside the Larry Canyon Area of Critical Environmental Concern (ACEC) which was established to prioritize the management of the riparian habitat therein. Lousy Canyon is inside the Perry Mesa ACEC which was established to prioritize the management of cultural resources. Silver Creek is just north of the northern boundary of the Perry Mesa ACEC.

Wild and Scenic Rivers: The Agua Fria River, including the confluences with Silver Creek, Lousy Canyon and Larry Creek, is proposed for designation as a wild reach in the Arizona Statewide Wild and Scenic Rivers Legislative Environmental Impact Statement, December, 1994.

Land Ownership/Private Property Rights: None of the proposed fish reintroduction sites have any private lands. The upper end of Silver Creek is located on the Tonto National Forest. The remaining portion of Silver Creek and all of Lousy Creek and the Tributary to Larry Creek are located on BLM-administered public lands. Patented lands owned by the Horseshoe Ranch are located immediately north of the lower end of Silver Creek. Private lands are located along the Agua Fria River downstream of all three reintroduction sites. Map 2 depicts of land ownership in the vicinity of the reintroduction sites.

Neither desert pupfish nor Gila topminnow presently occur within the project area although it lies within the historic range of both species. Both species are believed to have been extirpated from the area due to the spread of exotic fishes and the slow "winking-out" of remaining isolated populations due to droughts, fires, or other stochastic events. Only a few isolated sites, such as these proposed for reintroduction, remain inhabitable for either or both of these species. There is no nearby population of desert pupfish to the project area. The nearest populations of Gila topminnow occur at AD Wash, Tule

Map 2.


Horseshoe Ranch
Cross Y Ranch
Bumble Bee Ranch
MAP 2.
Land Ownership

Creek, and possibly Cow Creek, which drain into Lake Pleasant. They are isolated from the project area by Lake Pleasant and its formidable population of exotic predators.

EFFECTS OF THE ACTION

Desert Pupfish

Effects of removal from Donor Population

Desert pupfish are intended to come from Santa Clara Slough stock from Dexter National Fish Hatchery and Technology Center. The purpose of the stock at Dexter is for reintroduction and other recovery purposes. Depletion of the stock is not likely to have any noticeable consequences there.

Productivity/Mortality

Three new desert pupfish populations would become established in a 2.5 mile reach of Silver Creek, a 1.5 mile reach of Lousy Canyon, and a 0.6 mile reach of the tributary to Larry Canyon. These are three mid-elevation desert streams that typically have high primary productivity and good potential to produce large populations of pupfish. Larry Creek tributary is shallower, with less habitat diversity, and may have a slightly lower chance for success, due to fewer pools. Mortality of stocked pupfish is likely to occur as a result of Gila chub and other native predators in all three stocking sites. Predation by nonnative fish is expected if pupfish move downstream from the stocking sites, past the natural barriers, and into habitat occupied by green sunfish and other exotic fish.

Effects of Road Crossings

The upper road crossing along Silver Creek is lightly traveled, is over bedrock, a geologic control for the stream, and is an approximately two inch deep riffle unlikely to be occupied by pupfish. Up or downstream effects of the crossing are unlikely, as the bedrock crossing is not likely to cause changes to the channel. The lower road crossing is an improved road that receives a great deal of traffic. The crossing is approximately two miles downstream of the likely normal dispersal limit of pupfish, and is occupied by green sunfish. The crossing is normally dry, and maintenance usually occurs when the stream is dry. Harm or death to pupfish by vehicles at the crossing would not likely occur.

Effects of Livestock Grazing

Livestock use of Silver Creek during the winter occurs for only two months, is dispersed, and is not expected to result in any measurable adverse effects to habitat for this species. Although there

is no recent range condition or watershed condition data, the area is lightly grazed, well-vegetated, and rested often. If the aquatic habitat were being adversely affected, which would be detected through monitoring, corrective actions would be initiated as is required by the Bureau's implementation of rangeland standards and guidelines. Evidence of changed or degraded channel morphology is not present and banks are nearly untouched by cattle. Although livestock do not spend much time in the creek, the opportunity for trampling or ingestion of topminnow exists, though is likely minimal. Livestock do not use Larry Creek tributary or Lousy Canyon. The rimrock terrain surrounding both sites prevents access by cattle. The watershed of the latter two reintroduction sites is well vegetated and very small (mostly below the canyon rims).

Effects of Prescribed Burning

Prescribed burns are periodically conducted on grasslands adjacent to the stocking sites. BLM completed an environmental assessment for the prescribed fire program in the Agua Fria grasslands in 1994. Burns are carefully coordinated to burn the tobosa grass flatlands, not riparian areas or canyons. There are no 100 percent coverage fires. Mosaics are burned within the landscape. Coordination ensures only parts of watersheds are burned at any one time. Only light fugitive retardant is used on mesa tops, if needed. No cyanide based sodium ferrocyanide from heavy air tankers is used on the mesa. The burns could result in short term influxes of sediments, should heavy rains fall in the treated areas immediately after burning. The reintroduction sites, however, are within buffers of unburned canyon slopes which would greatly reduce any sediments reaching live water except during the rarest heavy thunderstorm events soon after a burn. The long term effects of prescribed burns would improve watershed function by producing more herbaceous ground cover to protect the soils and facilitate groundwater infiltration. Native fishes occur in all three reintroduction sites and, although prescribed fires have occurred in close proximity to the sites, no adverse impacts to the fish or stream habitat have been observed since prescribed burning began.

Effect of Area of Critical Environmental Concern (ACEC)

The Larry Creek tributary is inside the Larry Canyon ACEC. The focus of this ACEC is protecting riparian habitat. The Lousy Canyon reintroduction site is in the Perry Mesa ACEC which was established to protect cultural resources. Protection of both areas is focused on minimizing surface-disturbing activities. This should benefit the watershed, riparian habitat, and stream channel morphology of both reintroduction sites.

Effects of Recreation

Recreational use of Lousy Canyon and Larry Creek is very infrequent and is from hardy hikers. Vehicular access cannot be made and walking access to both of these sites is difficult. Recreational use of Silver Creek is light. It consists of dispersed use associated with equestrian

use and small and big game hunting. Both of these types of use lend themselves more to open country and "edge," and not to the stream itself. Off highway vehicle use is very restricted in the ACECs, and both Larry and Lousy Canyons are inaccessible. Vehicle use in Silver Creek is restricted to existing roads, and trails receive light use. Current levels of recreation likely have an immeasurable effect on the species.

Wild and Scenic Rivers

The Agua Fria River, including the confluences with Silver Creek, Lousy Canyon, and Larry Creek, is proposed for designation as a wild reach in the *Arizona Statewide Wild and Scenic Rivers Legislative Environmental Impact Statement*, completed in December, 1994. Wild status would add additional protections downstream of all three reintroduction sites, but would not likely affect them due to the geologic barriers upstream of each confluence. If the designation were to bring in additional recreation, visitation would not likely increase far from the Agua Fria Mainstem because the reintroduction sites are relatively inaccessible.

Land Ownership/Private Property

All reintroduction sites are on BLM or U.S. Forest Service lands downstream to the tributaries of the Agua Fria River. Private lands occur downstream of all reintroduction sites. Because of the hostile nature of predatory fish in the Agua Fria River toward this species, it is not expected that any pupfish would reach or occupy the private lands downstream, but would perish soon after entering the Agua Fria mainstem, if not before. Therefore, there is no expectation that actions on the private lands downstream of the reintroduction sites would affect the species.

Gila Topminnow

Effects of Removal from Donor Population

The three donor sites, Coal Mine Canyon, Fresno Canyon, and Lower Sonoita Creek are all in the same drainage. Taking donor stock from each site would help ensure any genetic variation is replicated and that no single site is over-harvested. Additionally, collections from these sites would be in the May-June period, after considerable recruitment has occurred and the populations are reaching their peaks.

Productivity/Mortality

Three new Gila topminnow populations would become established in a 2.5 mile reach of Silver Creek, a 1.5 mile reach of Lousy Canyon and a 0.6 mile reach of the tributary to Larry Canyon. These are three mid-elevation desert streams that typically have high primary productivity and good potential to produce large populations of topminnow. Larry Creek tributary is shallower,

with less habitat diversity, and may prove slightly less productive. Mortality of stocked topminnow is likely to occur as a result of Gila chub and other native predators in all three stocking sites. Predation by nonnative fish is expected if topminnow move downstream from the stocking sites, past the natural barriers, and into habitat occupied by green sunfish and other exotic fish.

Effects of Road Crossings

The upper road crossing along Silver Creek is lightly traveled, is over bedrock, a geologic control for the stream, and is an approximately two inch deep riffle unlikely to be occupied by topminnows. Up or downstream effects of the crossing are unlikely, as the bedrock crossing is not likely to cause changes to the channel. The lower road crossing is an improved road that receives a great deal of traffic. The crossing is approximately two miles downstream of the likely normal dispersal limit of topminnows, and occupied by green sunfish. The crossing is normally dry, and maintenance of the crossing usually occurs when the stream is dry. Harm or death to topminnows by vehicles at the crossing would not likely occur.

Effects of Livestock Grazing

Livestock use of Silver Creek during the winter occurs for only two months, is dispersed, and not expected to result in any measurable adverse impact to habitat for this species. Although there is no recent range condition or watershed condition data, the area is lightly grazed, well-vegetated, and rested often. If the aquatic habitat were being adversely affected, which would be detected through monitoring, corrective actions would be initiated as is required by the Bureau's implementation of rangeland standards and guidelines. Evidence of changed or degraded channel morphology is not present and banks are nearly untouched by cattle. Although livestock do not spend much time in the creek, the opportunity for trampling or ingestion of topminnow exists, though is likely minimal. Livestock do not use Larry Creek tributary or Lousy Canyon. The rimrock terrain surrounding both sites prevents access by cattle. The watershed of the latter two reintroduction sites is, therefore, well vegetated and very small (mostly below the canyon rims).

Effects of Prescribed Burning

Prescribed burns are periodically conducted on grasslands adjacent to the stocking sites. BLM completed an environmental assessment for the prescribed fire program in the Agua Fria grasslands in 1994. Burns are carefully coordinated to burn the tobosa grass flatlands, not riparian areas or canyons. There are no 100 percent coverage fires. Mosaics are burned within the landscape. Coordination ensures only parts of watersheds are burned at any one time. Only light fugitive retardant is used on mesa tops, if needed. No cyanide based sodium ferrocyanide from heavy air tankers is used on the mesa. The burns could result in short term influxes of sediments, should heavy rains fall in the treated areas immediately after burning. The reintroduction sites,

however, are within buffers of unburned canyon slopes which would greatly reduce any sediments reaching live water except during the rarest heavy thunderstorm events soon after a burn. The long term effects of prescribed burns would improve watershed function by producing more herbaceous ground cover to protect the soils and facilitate groundwater infiltration. Native fishes occur in all three reintroduction sites and, although prescribed fires have occurred in close proximity to the sites, no adverse impacts to the fish or stream habitat have been observed since prescribed burning began.

Effect of Area of Critical Environmental Concern (ACEC)

The Larry Creek tributary is inside the Larry Canyon ACEC. The focus of this ACEC is protecting riparian habitat. The Lousy Canyon reintroduction site is in the Perry Mesa ACEC which was established to protect cultural resources. Protection of both areas is focused on minimizing surface-disturbing activities. This should benefit the watershed, riparian habitat, and stream channel morphology of both reintroduction sites.

Effects of Recreation

Recreational use of Lousy Canyon and Larry Creek is very infrequent and is from hardy hikers. Vehicular access cannot be made and walking access to both of these sites is difficult. Recreational use of Silver Creek is light. It consists of dispersed use associated with equestrian use and small and big game hunting. Both of these types of use lend themselves more to open country and "edge," and not to the stream itself. Off highway vehicle use is very restricted in the ACECs, and both Larry and Lousy Canyons are inaccessible. Vehicle use in the Silver Creek is restricted to existing roads, and trails receive light use. Current levels of recreation likely have an immeasurable effect on the species.

Wild and Scenic Rivers

The Agua Fria River, including the confluences with Silver Creek, Lousy Canyon, and Larry Creek, is proposed for designation as a wild reach in the *Arizona Statewide Wild and Scenic Rivers Legislative Environmental Impact Statement*, completed in December, 1994. Wild status would add additional protections downstream of all three reintroduction sites, but would not likely affect them due to the geologic barriers upstream of each confluence. If the designation were to bring in additional recreation, visitation would not likely increase far from the Agua Fria mainstem because the reintroduction sites are relatively inaccessible.

Land Ownership/Private Property

All reintroduction sites are on BLM or U.S. Forest Service lands downstream to the tributaries of the Agua Fria River. Private lands occur downstream of all reintroduction sites. Because of

the hostile nature of predatory fish in the Agua Fria River toward this species, it is not expected that any topminnow would reach or occupy the private lands downstream, but would perish soon after entering the Agua Fria mainstem, if not before. Therefore, there is no expectation that actions on the private lands downstream of the reintroduction sites would affect the species.

Effect of desert pupfish and Gila topminnow on each other

Historically, both species were distributed throughout much of the Gila River system, and records show the two species living sympatrically at some sites. The Gila topminnow spends much of its time in the top of the water column, while the desert pupfish tends to use the mid-column and bottom. Both species are omnivorous with wide food use. Production all three reintroduction sites should be sufficient to support large numbers of both species.

CUMULATIVE EFFECTS

Cumulative effects include the effects of future State, tribal, local or private actions that are reasonably certain to occur in the action area considered in this biological opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the Act. All three of the proposed reintroduction sites are on public lands administered by BLM. The upper end of Silver Creek is located on the Tonto National Forest. The remaining portion of Silver Creek and all of Lousy Creek and the Tributary to Larry Creek are located on BLM-administered public lands. Patented lands owned by the Horseshoe Ranch are located immediately north of the lower end of Silver Creek. Private lands are located along the Agua Fria River downstream of all three reintroduction sites. Neither desert pupfish nor Gila topminnow are expected to survive if they reach the Agua Fria River, due to predation. No actions that could affect these species are expected to occur that would be without a Federal nexus.

CONCLUSION

After reviewing the current status of the Gila topminnow, *Poeciliopsis occidentalis occidentalis* and the desert pupfish, *Cyprinodon macularius*, the environmental baseline for the action area, the effects of the proposed reintroduction of Gila topminnow and desert pupfish into three tributaries of the Agua Fria River, and the cumulative effects, it is the Service's biological opinion that the action, as proposed, is not likely to jeopardize the continued existence of the Gila topminnow or the desert pupfish. No critical habitat has been designated for the Gila topminnow, therefore, none will be affected. Critical habitat for the desert pupfish has been designated at Quitobaquito Spring and three locations in Imperial County, California, however, this action does not affect those areas and no destruction or adverse modification of that critical habitat is anticipated.

The proposed reintroduction of desert pupfish and Gila topminnow into the three sites identified would result in some of the fish being eaten by Gila chubs and green sunfish, and other predators. Relatively few of each species would possibly be sporadically adversely affected by existing activities, i.e., road crossings, prescribed fires, and livestock grazing, but an overwhelming majority of the fish are expected to survive and with the augmentation of supplemental stockings, as necessary, become established in relatively secure environments. Desert pupfish and Gila topminnow have a relatively high reproductive potential and these populations, once established, will likely absorb the anticipated take with minimal adverse impact to the populations as a whole. The populations are expected to thrive with the current level of ongoing activities, and contribute to recovery of each species.

INCIDENTAL TAKE STATEMENT

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the Act prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Harass is defined by the Service as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The measures described below are non-discretionary, and must be undertaken by BLM so that they become binding conditions of any grant or permit issued to an applicant, as appropriate, for the exemption in section 7(o)(2) to apply. BLM has a continuing duty to regulate the activity covered by this incidental take statement. If BLM (1) fails to assume and implement the terms and conditions or (2) fails to require an applicant to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, BLM must report the progress of the action and its impact on the species to the Service as specified in the incidental take statement. [50 CFR §402.14(i)(3)]

AMOUNT OR EXTENT OF TAKE

The Service anticipates that the proposed project would result in incidental take of desert pupfish and Gila topminnow through direct mortality during capture, transport, holding, and stocking, and

through direct and indirect mortality, harm, and harassment of individuals due to ongoing activities in the action area. The Service anticipates that mortality will not be greater than an estimated 25 percent of each species being captured, stocked, held, or transported during any given action, including supplemental stocking.

The Service anticipates incidental take of desert pupfish and Gila topminnow in the form of harassment, harm, and kill is expected from livestock grazing, recreation activities, road use, and prescribed burning. The take from these ongoing activities will be difficult to detect for these ongoing activities for the following reasons: each species has small body size; each occurs in complex habitat of water, debris, and emergent vegetation; finding a dead or impaired specimen is unlikely; and losses may be masked by seasonal fluctuations in numbers or other causes, such as sedimentation. However, the above level of take of these species can be anticipated by noticeable kill of any species of fish, streambank alteration rating over 10%, woody riparian species utilization over 30% of any seedlings under 3 feet, or loss of bank cover due to causes other than natural wildfire or flood, immediately following a covered ongoing action in the project area, because these surrogates would be affected by the activities that would likely cause take.

EFFECT OF THE TAKE

In the accompanying biological opinion, the Service determined that this level of anticipated take is not likely to result in jeopardy to the desert pupfish or Gila topminnow, or destruction or adverse modification of critical habitat.

REASONABLE AND PRUDENT MEASURES

The Service believes the following reasonable and prudent measures are necessary and appropriate to minimize take of desert pupfish and Gila topminnows:

1. Conduct ongoing actions in a manner which reduces habitat disturbance or disturbance or death to individuals. Most likely incidental take is related to the habitat surrogates defined above.

2. Provide a means to determine the level of incidental take that actually results from the project.

TERMS AND CONDITIONS

In order to be exempt from the prohibitions of section 9 of the Act, BLM must comply with the following terms and conditions, which implement the reasonable and prudent measures described above and outline required reporting/monitoring requirements. These terms and conditions are non-discretionary.

1.1 Notify the Service prior to stocking the sites. Use of Gila topminnows from other stocks or sources is permissible, and mixing of stocks may be suggested for conservation purposes in the future.

1.2 At Silver Creek, ensure grazing or recreational activity is managed such that less than 10 percent of streambanks are altered, that there is no loss of streambank cover from the present level, and that browsing on woody riparian seedlings is less than 30 percent.

1.3 Conduct prescribed burns such that no more than one-half of the watershed of each reintroduction site is burned in a two year period (excluding buffers to the streams) and repeat treatment at greater than two-year intervals.

2.1 At Silver Creek, monitor vegetation and streambanks of each site once each year, using accepted BLM methods.

2.2 Monitor desert pupfish and Gila topminnow populations and appropriate aquatic habitat variables at least once each year. Use accepted protocols in cooperation with AGFD and the Service with respect to augmentation periods and extirpation evaluations.

2.3 Monitor for fish kill immediately following the first runoff event after prescribed fires in the watershed.

2.4 A short report of the results of the monitoring, including complete and accurate records of all incidental take that occurred during the course of the project, will be submitted to the Service annually on the anniversary of the accompanying biological opinion. This report will also describe how the terms and conditions in this incidental take statement were implemented with respect to livestock grazing, recreation use, road use, and prescribed burns. This report may be consolidated with others or reports from sources than BLM may be acceptable as long as they address the above requirements.

The reasonable and prudent measures, with their implementing terms and conditions, are designed to minimize the impact of incidental take that might otherwise result from the proposed action. If, during the course of the action, this level of incidental take is exceeded, such incidental take represents new information requiring reinitiation of consultation and review of the reasonable and prudent measures provided. The Federal agency must immediately provide an explanation of the causes of the taking and review with the Service the need for possible modification of the reasonable and prudent measures.

DISPOSITION OF DEAD, INJURED, OR SICK INDIVIDUALS OF A LISTED SPECIES

If a dead, injured, or sick individual of a listed species is found at the project sites, initial notification must be made to Service Law Enforcement, Federal Building, Room 105, 26 North McDonald, Mesa, Arizona, 85201 (Telephone: 602/261-6443) within three working days of its finding. Written notification must be made within five calendar days and include the date, time, and location of the finding, a photograph of the animal, and any other pertinent information. The notification shall be sent to Law Enforcement with a copy to the Arizona Ecological Services Field Office. Care must be taken in handling sick or injured animals to ensure effective treatment and care, and in handling dead specimens to preserve biological material in the best possible state. If possible, the remains shall be placed with educational or research institutions holding appropriate State and Federal permits. If such institutions are not available, the information noted above shall be obtained and the carcass left in place.

Arrangements regarding proper disposition of potential museum specimens shall be made with the institution prior to implementation of the action. Injured animals should be transported to a qualified veterinarian by an authorized biologist. Should any treated animals survive, the Service shall be contacted regarding the final disposition of the animals.

CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

BLM's proposed project is directly aimed at 7(a)(1) responsibilities. The Service recognizes the great value of this undertaking and appreciates BLM's effort in this regard. In addition to this action, BLM could assist the Arizona Game and Fish Department in its monitoring program of extant populations of this species and identify more sites applicable to reintroduction in order to facilitate recovery of this species.

BLM could formalize a fire management protocol for all aspects of fire, prescribed and wild, that would be aimed at protecting the reintroduction and natural pupfish and topminnow sites on public land.

In order for the Service to be kept informed of actions minimizing or avoiding adverse effects or benefitting listed species or their habitats, the Service requests notification of the implementation of any conservation recommendations.

REINITIATION NOTICE

This concludes formal consultation on the action(s) outlined in the request. As provided in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation.

The Service appreciates BLM's efforts on this project. This reintroduction will benefit the recovery of both species. For further information please contact Doug Duncan, Mike Coffeen, or Tom Gatz. Please refer to the consultation number, 2-21-99-F-031, in future correspondence concerning this project.

David L. Harlow

cc: Regional Director, Fish and Wildlife Service, Albuquerque, NM (ES)
State Director, Bureau of Land Management, Phoenix, AZ
Field Manager, Bureau of Land Management, Safford, AZ
Field Manager, Bureau of Land Management, Tucson, AZ
Director, Arizona Game and Fish Department, Phoenix, AZ

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LITERATURE CITED

Barlow, G. W. 1958. Daily movements of desert pupfish, *Cyprinodon macularius*, in shore pools of the Salton Sea, California. Ecology 39:580-587.

Barlow, G.W. 1961. Social behavior of the desert pupfish, *Cyprinodon macularius*, in the field and in the aquarium. Am. Midl. Nat. 65:330-359.

Black, G.F. 1980. Status of the desert pupfish, *Cyprinodon macularius* (Baird and Girard), in California. California Dept. Fish and Game, Inland Fisheries, Endangered Species Proj., Rancho Cordova.

Bureau of Land Management. 1993. Riparian area management: Process for assessing proper functioning condition. Tech. Ref. 1737-9. Denver, Colorado. 51pp.

Bureau of Land Management. 1994. Arizona Statewide Wild and Scenic Rivers Legislative Environmental Impact Statement. Phoenix, Arizona.

Coleman, G.A. 1929. A biological survey of the Salton Sea. California Fish and Game 15:218-227.

Constantz, G.D. 1980. Energetics of viviparity in the Gila topminnow (Pisces: Poeciliidae). Copeia 1980:676-678.

Constantz, G.D. 1981. Life history patterns of desert fishes. Pages 237-290 *in* R.J. Naiman and D.L. Soltz, eds. Fishes in North American Deserts. John Wiley and Sons, Inc., New York.

Cox, T.J. 1966. A behavioral and ecological study of the desert pupfish (*Cyprinodon macularius*) in Quitobaquito Springs, Organ Pipe Cactus National Monument, Arizona. Ph.D. Diss., University of Arizona, Tucson.

Cox, T.J. 1972. The food habits of desert pupfish (*Cyprinodon macularius*) in Quitobaquito Springs, Organ Pipe Cactus National Monument, Arizona. J. Ariz.-Nev. Acad. Sci. 7:25-27.

Crear, D. and I. Haydock. 1971. Laboratory rearing of desert pupfish, *Cyprinodon macularius*. Fishery Bull. 69:151-156.

Deacon, J.E. and W.L. Minckley. 1974. Desert fishes. in G.W. Brown, Jr.(editor), Desert Biology, Vol. 2. Academic Press, New York.

Eigenmann, C.H., and R.S. Eigenmann. 1888. *Cyprinodon californiensis* Girard. Western American Sci. 5:3-4.

Evermann, B.W. 1916. Fishes of the Salton Sea. Copeia 1916:61-63.

Garman, S. 1895. The cyprinodonts. Memoirs of the Mus. of Comp. Zool. 19:1-179.

Gilbert, C.H., and N.B. Scofield. 1898. Notes on a collection of fishes from the Colorado Basin in Arizona. Proc. U.S. Natl. Mus. 20:487-499.

Hubbs, C.L. and R.R. Miller. 1941. Studies of fishes of the order Cyrpinodontes. XVII - genera and species of the Colorado River system. Occasional Papers of the Museum of Zoology, University of Michigan 433:1-9/

Jaeger, E.C. 1938. The California deserts. A visitor's handbook. Stanford University Press, Palo Alto, California.

Jordan, D.S. 1924. A topminnow (*Cyprinodon browni*) from an artesian well in California. Proc. Acad. Sci. Philadelphia 76:23-24.

Kinne, O. 1960. Growth, food intake, and food conversion in a euryplastic fish exposed to different temperatures and salinities. Physiol. Zool. 33:288-317.

Kodric-Brown, A. 1981. Variable breeding systems in pupfishes (genus *Cyprinodon*): adaptations to changing environments. Pages 205-235 in R.J. Naiman and D.L. Soltz, eds. Fishes in North American Deserts. John Wiley and Sons, Inc., New York.

Kynard, B.E., and R. Garrett. 1979. Reproductive ecology of the Quitobaquito pupfish from Organ Pipe Cactus National Monument, Arizona. Pages 625-629 in R.M. Linn, ed. Proc. of the First Conf. On Scientific Res. in the National Parks. Trans. and Proc. Number 5, Washington, DC.

Lowe, C.H., D.S. Hinds, and E.A. Halpern. 1967. Experimental catastrophic selection and tolerances to low oxygen concentrations in native Arizona freshwater fishes. Ecology 2:53-59.

Lowe, C.H., and W.G. Heath. 1969. Behavioral and physiological responses to temperature in the desert pupfish, *Cyprinodon macularius*. Physiol. Zool. 42:53-59.

McMahon, T.E., and R.R. Miller. 1985. Status of the fishes of the Rio Sonoyta basin, Arizona and Mexico. Proc. Desert Fishes Council XIV(1982):237-245.

Meffe, G.K. and F.F. Snelson, Jr. 1989. An ecological overview of poeciliid fishes. Pp. 13-31 in Meffe, G.K. and F.F. Snelson, Jr., eds., *Ecology and Evolution of Livebearing Fishes*. Prentic Hall, Englewood Cliffs, NJ.

Meffe, G.K., D.A. Hendrickson and W.L. Minckley. 1983. Factors resulting in decline of the endangered Sonoran topminnow *Poeciliopsis occidentalis* (Atheriniformes: Poeciliidae) in the United States. Biol. Conser. 25:135-159.

Miller, R.R. 1943. The status of *Cyprinodon macularius* and *Cyprinodon nevadensis*, two desert fishes of western North America. Occasional Papers Mus. Zool., Univ. of Michigan 473:1-25.

Miller, R.R., and L.A. Fuiman. 1987. Description and conservation status of *Cyprinodon macularius eremus*, a new subspecies of pupfish from Organ Pipe Cactus National Monument, Arizona. Copeia 1987(3):593-609.

Minckley, W.L. 1969. Aquatic biota of the Sonoita Creek basin, Santa Cruz County, Arizona. Ecol. Stud. Leafl. 15:1-8.

Minckley, W.L. 1973. *Fishes of Arizona*. Arizona Game Fish, Phoenix, AZ. 293 p.

Minckley, W.L., J.N. Rinne, and J.E. Johnson. 1977. Status of the Gila topminnow and its co-occurrence with mosquitofish. U.S. Forest Service Research Paper. RM-198:1-8 Rocky Mountain Forest and Range Experimental Station, Fort Collins, Colorado.

Minckley, W.L. 1980. *Cyprinodon macularius* Baird and Girard. Desert pupfish. Page 497 in D. S. Lee, C. R. Gilbert, C.H. Hocutt, R.E. Jenkins, D.E. McAlister, and J.R. Stauffer, Jr., eds. Atlas of North American Freshwater Fishes. North Carolina Mus. Nat. Hist., Raleigh.

Moyle, P.B. 1976. *Inland Fishes of California*. Univ. of California Press, Berkeley and Los Angeles, CA.

Naiman, R.J. 1979. Preliminary food studies of *Cyprinodon macularius* and *Cyprinodon nevadensis* (Cyprinodontidae). Southwestern Naturalist 24:538-541.

Pister, E.P. 1996. Threatened *Cyprinodon*. http://www.utexas.edu/depts/tnhc/.www/fish/dfc/gifs/dfctile.gif (30 Dec. 1996).

Schoenherr, A.A. 1974. Life history of the topminnow *Poeciliopsis occidentalis* (Baird and Girard) in Arizona and an analysis of its interaction with the mosquitofish *Gambusia affinis* (Baird and Girard). Ph.D. Diss., Ariz. State Univ., Tempe, AZ.

Thompson, W.F. 1920. Investigation of the Salton Sea. California Fish and Game 6:83-84.

Turner, B.J. 1983. Genic variation and differentiation of remnant natural populations of the desert pupfish, *Cyprinodon macularius*. Evolution 37:690-700.

U.S. Department of the Interior. 1967. Endangered and Threatened Wildlife and Plants. Fed. Reg. 32(48):4001

U.S. Fish and Wildlife Service. 1984. Endangered and threatened wildlife and plants; proposed endangered status and critical habitat for the desert pupfish (*Cyprinodon macularius*). Fed. Reg. 49(96):20739-20744.

U.S. Fish and Wildlife Service. 1986. Endangered and threatened wildlife and plants; determination of endangered status and critical habitat for the desert pupfish. Fed. Reg. 51(61):10842-10851.

U.S. Fish and Wildlife Service. 1991. Endangered and threatened species of Arizona (with 1992 addendum). U.S. Fish and Wildlife Service, Phoenix, Arizona.

U.S. Fish and Wildlife Service. 1993. Desert pupfish (*Cyprinodon macularius*) recovery plan. U.S. Fish and Wildlife Service, Region 2, Albuquerque, NM.

Vrijenhoek, R.C., M.E. Douglas, and G.K. Meffee. 1985. Conservation genetics of endangered fish populations in Arizona. Science 229:400-402.

Williams, J.E., J.E. Johnson, D.A. Hendrickson, S. Contreras-Balderas, J.D. Williams, M. Navarro-Mendoza, D.E. McAllister, and J.E. Deacon. 1989. Fishes of North America endangered, threatened, or of special concern. Fisheries 14(6):2-20.